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Transmitted herewith for filing under 35 U.S.C. 111 and 37 C.F.R. 1.53 is the patent application of:

FINGERHUT et al.

For: **NETWORK TRAFFIC ANALYZER**

Enclosed are:


- ☐ Certificate of Mailing with Express Mail Mailing Label No.
- ☒ **Eleven (11)** sheets of drawings.
- ☐ A certified copy of a _____ application.
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APPLICATION FOR UNITED STATES LETTERS PATENT

for

NETWORK TRAFFIC ANALYZER

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NETWORK TRAFFIC ANALYZER

BACKGROUND

Field of the Invention

The present invention is directed to managing and monitoring traffic and capacity in a packet-switched digital network. More particularly, the present invention is directed to capturing traffic log data, and graphically displaying network operation characteristics based on the traffic log data.

Background of the Invention

Mobitex is a digital wireless data network technology that was developed in 1984 and has since seen explosive growth. The Mobitex wireless network technology is recognized as an international data communication standard. It is a secure, reliable, two-way digital wireless packet switching network ideal for a variety of data communication applications, such as email and information broadcasting.

Presently there are 28 Mobitex networks operating in 22 countries throughout the world.

Figure 1 shows a typical Mobitex network 100 which has a pyramidal topology with a single Network Control Center (NCC) 10, a national exchange 15, several regional exchanges 20 (referred to herein as "MHXs"), several local exchanges 30 (referred to herein as "MOXs") and hundreds (or even thousands) of base stations 40 linked, or interconnected, to each other using high speed conventional or fiber optic or microwave communications links. ("MHX" and "MOX" are Swedish acronyms and are well known to those skilled in the art.) Wireless devices communicate with a base station 40 with which it has the best available signal strength. Also,

hosts 60a, 60b (e.g., a customer's computer, gateway, etc.) can be connected to Mobitex network 100 via, for example, the well-known X.25 communication protocol, using either dedicated leased circuits or public data networks.

To connect to Mobitex network 100, each radio modem in wireless device 50, or host 60 must have an active Mobitex Access Number (MAN). A MAN is assigned to every user (or device) subscribing (connected) to the Mobitex network. A MAN is analogous to a phone number on a telephone network. Thus, the MAN for a mobile user is stored in the mobile device's radio modem, just as a telephone number is stored inside a cellular phone.

Mobitex network 100 uses a packet-switching technique to transmit data. Each packet in the Mobitex network is called an MPAK (short for "Mobitex packet") and can have no more than 512 bytes of data. Messages longer than 512 bytes are divided into multiple packets. MPAKs include information about the origin, destination, size, type, and sequence of data to be sent, enabling packets to be transmitted individually, in any order, as traffic permits. Individual packets may travel along different routes, in any order, without interfering with other packets sent over the same frequency by different users. At the receiving end, all packets are accounted for, and reassembled into the original message. Further information about the technical aspects of a conventional Mobitex network can be found in Mobitex Interface Specification (MIS), Ericsson Mobile Data Design AB, Gothenburg, Sweden.

In order to provide network customers with reliable communications service, a network operator is often interested in learning whether capacity remains in the network and/or whether an overload condition has been reached. For this purpose, a conventional Mobitex network implements an alarm scheme to alert personnel at NCC 10 that a problem has been detected in

the network. More specifically, each level of network 100 and the interconnecting links all have predetermined capacities. Existing Mobitex tools permit NCC personnel to set alarm condition thresholds with respect to, for example, MPAKs per hour or MPAKs per ten minute period, that travel through a particular network device. If a threshold is exceeded, the NCC receives an alarm that indicates, for example, that a particular base station 40 or MOX 30 exceeded the threshold. NCC 10 may subsequently receive an alarm indicating that the traffic level has fallen below the alarm threshold.

Each of these alarm events is, generally, displayed on a computer screen at NCC 10, one line per alarm. In a typical network of, for example, 2,000 base stations, 80 MOXs and six MHXs, alarms tend to scroll across the display screen without affording NCC personnel any true insight into the state of the network. Indeed, the amount of alarm information can be overwhelming.

To improve on the foregoing network alarm scheme, filters have been implemented to pick out alarms that represent specific information of interest, and display only those alarm events on a separate display screen, or store them in a separate file for later analysis. However, even with the implementation of filters, a network engineer may still have difficulty obtaining real-time or substantive analysis information for purposes of trouble-shooting or monitoring network operations. Indeed, alarm thresholds are often set artificially low and used primarily to indicate when capacity needs to be added. These alarms, therefore, tend to be even less meaningful. Thus, using existing alarm tools, it is apparent from the foregoing that a network engineer cannot “watch” what is happening in network 100. He can only know when a threshold has been hit.

One way to obtain a better view into network 100 is to periodically poll each of the devices in the network. Unfortunately, when this is done, additional traffic is created, thereby decreasing the amount of capacity that is available for customer use. Often such polling from the NCC has priority over customer traffic, thereby effectively ensuring that paying customers are undesirably blocked out of the network.

Accordingly, there remains a need for network analysis tools that can provide real-time or near real-time graphical display of the operations of a network, and particularly a Mobitex network, without adding more traffic to the network itself.

SUMMARY OF THE INVENTION

The present invention provides a network engineer with true insight into a packet-switched network by exploiting traffic logs that are automatically generated and collected at a Network Control Center (NCC). One feature of a Mobitex network is that each time an MPAK exits the network, a traffic log is created. A traffic log contains the MPAK's entry point, the MPAK's exit point, the MANs of the sender and recipient, the MPAK's type (e.g., text, data, etc.) and its state (e.g., OK, illegal, error, etc). Other pieces of information include packet length, number of nodes, time of use, subscription type and network resources used. In a conventional Mobitex network, traffic logs (sometimes numbering in the millions per day) are passed up through network 100 and collected at NCC 10. Typically, traffic logs are used as the data source for customer billing. However, in the present invention, traffic logs are exploited to provide insight into the health of the network.

While the present invention is described with respect to a Mobitex network, those skilled in the art will appreciate that the invention is applicable to any packet-switched network in which

traffic logs or similar information or data is collected at a central location or can be retrieved from distributed locations. Such networks include, for example GSM, CDPD, GPRS, Ardis and Reflex.

The present invention, a traffic analyzer (also referred to herein as "TRANAL" for Traffic ANALyzer) is designed to provide a "window" into the operation of a packet-switched network (and in particular a Mobitex network) by gleaning information from traffic logs and graphically displaying the information in readily understandable ways. Prior to TRANAL, information concerning the state of the network was presented only in the form of alarms. However, alarms are only indicators of immediate problems within the network and therefore provide only limited information about conditions leading up to the problem. Accordingly, alarms are not always useful to predict potential trouble areas or to provide a real- or near-real time window into the network.

The present invention, on the other hand, provides a tool that can be used to monitor network conditions in near real-time. Overloads and congestion, for example, at a particular network node, or over a particular link, can be detected and corrected before they affect paying customers. In addition, the present invention can be used for network planning. Specifically, the charting or graphical display features of TRANAL facilitate trend analysis for each network node, as well as the entire network itself. Thus, high-traffic nodes and geographical areas can be more easily identified as areas where the network should be expanded.

In the preferred embodiment of the present invention, traffic logs generated by the network are analyzed and information that can be gleaned therefrom is presented or displayed to user in a graphical form. In Mobitex networks operating today, traffic logs are created

throughout the network and are accumulated automatically at NCC 10. As discussed above, these traffic logs have been used primarily for billing. In accordance with the preferred embodiment of TRANAL, the traffic logs are captured as they arrive at the NCC. They are then processed and stored, and then are reprocessed as required into histogram data that can be viewed graphically as needed. For example, in the preferred embodiment, TRANAL displays a pair of histograms for a particular host. A first histogram or chart shows the MPAK traffic coming into the host over a predetermined period of time (e.g., 24 hours) and a second histogram or chart preferably shows the MPAK traffic leaving that host over the same period of time. Of course, one chart only may be displayed for a user, should that be desired. Also, the period of time over which the information is displayed can also be modified.

In addition to showing the traffic through a particular host, TRANAL preferably graphically shows traffic passing through any node (e.g., MOX, MHX) in the network. Specifically, Mobitex network 100 is a relatively well-defined network that seldom changes. That is, while base stations may be added, the addition of a MOX 30 (local switch) is relatively rare. It is even more rare that an MHX (regional switch) 20 is added. Accordingly, by looking only at entry and exit points of an MPAK (and/or its sender and recipient MANs) it is possible to determine the path that the MPAK takes through the network 100. By knowing the path, one can also thus determine which nodes (e.g., local switches, regional switch) the MPAK must have traveled through to reach its destination. Thus, TRANAL not only can graphically display host traffic flow, but it can also show traffic flow through any node of the network, as long as the network topology is known.

Similarly, in accordance with the preferred embodiment of the invention, the remaining capacity of, or alternatively, the traffic on, the links connecting the various nodes can also be

graphically displayed. A component of each traffic log includes the number of data bytes that the MPAK is carrying. Accordingly, it is possible to determine how many bytes or bits of information travel over a particular path or link over a specific period of time.

Thus, at least three different “windows” into the network are preferably provided by the present invention: host view, node view and link view. And preferably, each can be called up by a user on demand. TRANAL preferably also provides a full network traffic view that displays the MPAK traffic in the entire network over, e.g., a 24-hour period.

The preferred embodiment of the present invention is preferably implemented as a client-server system, wherein the server(s) store(s) all relevant data and the client requests or queries for data regarding a particular host, node or link. The data relevant to that query is then preferably broadcast over a network and any client that had previously requested such a data set will also receive it at that time.

It is therefore an object of the present invention to provide a method and system for analyzing a digital network using traffic log data.

It is yet another object of the present invention to provide a method and system for graphically displaying traffic in a digital network.

It is another object of the present invention to provide a method and system for obtaining, on-demand, a graphical display of network traffic.

It is also an object of the present invention to provide a method and system that preprocesses traffic log data so that information can be easily gleaned therefrom.

It is another object of the present invention to provide a method and system for monitoring and troubleshooting digital network problems.

It is still another object of the present invention to provide a method and system for providing capacity planning in a digital network.

5 It is another object of the present invention to provide a graphical display of network traffic through or on at least one of a host, a node or a link.

These and other objects of the present invention will become apparent upon a reading of the following detailed description in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic illustration of a Mobitex network.

Figure 2 shows the structure and components of a Mobitex traffic log.

Figure 3 is a schematic diagram of an implementation of the preferred embodiment of the present invention.

15 Figure 4 shows an exemplary traffic log storage structure for a host traffic view in accordance with the preferred embodiment of the present invention.

Figure 5 shows an exemplary traffic log storage structure for a node traffic view in accordance with the preferred embodiment of the present invention.

Figure 6 shows an exemplary traffic log storage structure for an overall network traffic view in accordance with the preferred embodiment of the present invention.

Figure 7 shows a logical structure for data to generate a histogram for a host view of traffic in accordance with the present invention.

Figure 8 is an exemplary pair of charts including histograms of traffic through a host, in accordance with the preferred embodiment of the present invention.

5 Figures 9-11 are flow diagrams illustrating preferred steps for practicing the present invention.

DETAILED DESCRIPTION OF THE INVENTION

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10 The present invention, also referred to herein as "TRANAL," provides a network engineer or manager insight into a packet-switched network such as a Mobitex network 100 such as the network shown in Figure 1. This insight is made possible through a unique use of traffic logs that are, in a network like a Mobitex network, automatically generated throughout network 100 and collected at a central location. More specifically, and in the case of a Mobitex network (although the principles of the present invention are applicable to any type of packet-switched network), a traffic log is automatically generated when an MPAK exits network 100. That is, 15 when an MPAK is first received by a MOX 30 (from a host 60) or a base station 40 (from a wireless device 50), or when an MPAK is transmitted from a MOX 30 or base station 40 (to a host 60, wireless device 50), the MOX 30 or base station 40, whichever last transmitted the MPAK, automatically generates a traffic log. Then, depending on the traffic through the MOX or base station, the traffic log is either immediately sent to NCC 10 or is stored for a limited period 20 of time (e.g., four hours) or until a buffer is filled with a predetermined number of logs (e.g., 25 logs). Ultimately, all traffic logs are collected at NCC 10 and, as a practical matter, most reach

NCC 10 within 5-10 minutes of their creation due to the sheer number of traffic logs that are created in a typical network 100.

The components of a traffic log are shown in Figure 2. More detailed information about Mobitex traffic logs can be found in Ericsson Network Operator Library Document #15518-CRH 109002 Uen REV E, 1999-12-23, which is hereby incorporated by reference in its entirety. As shown in Figure 2, a traffic log 200 typically includes a revision identifier 201 that identifies the revision of the signal, (e.g., format, of the traffic log), the A-party 202, which is typically the MAN of the sender, the time 204, which is the time the traffic log was created, the A-node 206, which is typically the node number of the node that first received the MPAK from the sender, the B-party 208, which is the MAN of the recipient, the B-node 210, which is the node number of the exit node associated with the recipient, the number of bytes 212, which is the number of bytes the MPAK contained, the turn node 214, which is the node number of the highest level node in the network through which the MPAK passed, the number of passed nodes 216, which is the number of nodes through which the MPAK has passed, the subscription type of the B-party and the A-party, 218, 220, the Mobitex packet class 222, the Mobitex packet type 224 (e.g., text, data, status, HPDATA (to identify data designated for a, e.g., a PALM VII or other non-standard device), the traffic state 226 (e.g. OK, from mailbox, in mailbox, no transfer, illegal, congest or error), and indication of positive acknowledgement 228.

As illustrated in Figure 3, traffic logs are generated in Mobitex network 100 by, e.g., base stations and MOXs within the network. For each MPAK that enters and exits network 100, one traffic log 200 is created. The logs are accumulated and passed to a computer server at NCC 10 in batches of, e.g., 25. Server 320 monitors the server at NCC 10 and detects when new logs have been stored in, e.g., database 310. Server 320 then employs FTP, or any other suitable data

transfer scheme, to retrieve the new logs. These logs are then parsed by server 320 and saved into a new format that is more easily analyzed. More specifically, the parsed and formatted traffic logs are stored, in accordance with one aspect of the present invention, in flat files as histogram data 330.

5 Users, or clients 340a-c, preferably communicate with server 320 via a TIBCO bus available from TIBCO Software, Inc., Palo Alto, CA. A TIBCO bus provides data broadcasting and addressing features that simplify the dissemination of the traffic information, typically a very large amount of data, to several users at the same time. For example, a user might want to view a histogram of the traffic at a particular host 60 for a given day. Thus, the user, via one of clients 10 340a-c, sends a request to server 320 for information about that host. Server 320 then broadcasts the requested host information for the current, or requested, day on the TIBCO bus. Whenever new information is obtained for that host (assuming the user requested information about the current day) the information is periodically re-broadcast and the clients are thus automatically updated. To reduce local network traffic, only those hosts specifically requested by clients are 15 broadcast on the bus.

 The following is a more detailed description of the preferred data storage and data structure implementations for TRANAL. Preferably, server 320 (Figure 3) actually comprises a server pool of at least two computers, each with 1024 MB of RAM and two 36 GB SCSI hard drives. These two drives or disks are preferably divided into 3 partitions, giving the server pool 20 access to 6 partitions in total, as shown in the table below.

Computer	Memory	Partition 1	Partition 2	Partition 3
TRANAL1	1 GB	8 GB	36 GB (Data Store)	28 GB (Traffic Logs)
TRANAL2	1 GB	8 GB	36 GB (Histograms)	28 GB (Backup)

TRANAL1 is primarily used to run a HostView Server (which broadcasts histogram data representative of MPAK traffic through hosts), organize log files, and perform administrative functions. TRANAL2 is primarily used to run a NodeView Server (which broadcasts histogram data representative of MPAK traffic through network nodes other than hosts).

The primary data source for TRANAL is a steady stream of binary traffic log files, which are delivered to TRANAL1, Partition 1 via File Transfer Protocol (FTP) (see Figure 3). These logs are deposited in a directory called ncc_traflog and remain there for, e.g., 2 days. At the same time they are copied into longer-term storage on TRANAL2, Partition 3 (backup).

TRANAL1 preferably copies these logs into three locations:

- TRANAL1, Partition 3 (Traffic Logs) for use by the HostView server
- TRANAL2, Partition 2 (Histograms) for use by the NodeView server
- TRANAL1, Partition 2 (Data Store) for use by a Parse by Hour process

Larger hard drives or an additional server can be added to the server pool to store histogram data for a LinkView server, which analyzes traffic and/or capacity in the links connecting each of the nodes in network 100. The HostView and NodeView servers create output files whose storage scheme is described below. The storage scheme for the LinkView output files is preferably similar to the NodeView storage scheme.

In the preferred embodiment of the present invention, TRANAL employs a flat-file storage structure, as opposed to a database (although as computing/processor speed increases and

data storage access times decrease, it is contemplated that the use of databases may also be employed). TRANAL pre-processes data in ways that will make it easy to fulfill the most common requirements, rather than every conceivable requirement. Accordingly, when data is required, access is fast and efficient. In contrast, a database is more suited for requests whose nature is more difficult to predict, and therefore, the data is stored and retrieved in a more generic, but less efficient manner. Flat files are binary files or text files which use the operating system's file system structure as the primary means of organization. Because of the very large amount of data that is processed by TRANAL on a daily basis, the use of flat files is preferable to the use of presently available relational database management systems. In TRANAL, data is preferably pre-processed into files which are organized by date. Each day has its own directory with the day's histogram information stored under it.

More specifically, server 320 reads in the binary traffic log files and simultaneously preferably processes them into daily histograms. These histograms are preferably stored in memory for 24 hours as they are being created. A histogram in accordance with the present invention preferably is representative of the number of MPAKs of the several states (as well as the total number of MPAKS) that pass through a given host (or node or link) over a predetermined period of time, e.g., 24 hours. The histogram preferably has a granularity (i.e., a timewise selectivity) of five minutes, though any desired granularity may be employed.

As the binary traffic logs are processed, they are preferably deleted from the disk (TRANAL1, Partition 3). In the preferred embodiment of the present invention, there is one pair of histograms for each host (customer) that uses network 100. Each pair of histograms represents traffic on that host for one day and is stored, preferably as a fixed length record, in one

file on disk as 19 KB of binary data. The histograms are stored on TRANAL1, Partition 3 in a directory structure as follows:

```
host histograms\  
  year\ (4-character form of the year the histogram was created)  
    month\ (2-character form of the month the histogram was  
      created)  
      mm_dd_yyyy\ (date of the histogram)  
        MAN.MOX.host (a file whose name includes  
          the MAN number, connecting MOX,  
          and ".host" file extension)
```

Figure 4 shows an example of a directory structure for host view. Note that some of the files in Figure 4 have the form xxxxx.0.host. The "0" MOX file is a file that is a histogram of MPAKs that traveled through a particular host from/to all of the MOXs that the host might be connected to. See in Figure 1 where a host 60b is connected to more than one MOX.

The NodeView server (a second server like server 320, but not shown in Figure 3) reads in the binary traffic log files and preferably processes them into daily histograms representative of node traffic. Like HostView histograms, NodeView histograms are preferably stored in memory for 24 hours as they are being created. To generate histograms for nodes, one can parse the traffic logs using the "turn node" and "number of passed nodes" components of the traffic log to determine the path of any one MPAK. Then, because a network like a Mobitex network is relatively static, it is possible to determine which nodes were used to carry any particular packet, or whether a particular node was used to carry a particular packet.

Alternatively, it is possible to identify in the traffic log the A-node and B-node or to identify the sender and recipient MANs which can indirectly identify the A-node and B-node. Then, knowing the A-node and B-node MANs, it is possible to "trace" the path of each of the MPAKs up through hierarchical network 100. Where the paths meet identifies an "apex" node

or turn node. Again, because a network like a Mobitex network is relatively static, it is possible to determine whether any particular node is located along the path that has been recreated. Then, the histogram for each node along the path can be updated.

As the binary traffic logs are processed, they are deleted from the disk (TRANAL2,

5 Partition 2). There is one pair of histograms for each node that makes up the Mobitex network. Each pair of histograms represents traffic on that node for one day and is stored in one file on disk as 19 KB of binary data. Several such files are stored on TRANAL2, Partition 2 in a directory structure similar to the HostView structure:

Histograms:\
 node histograms\
 year\ (4-character form of the year the histogram was created)
 month\ (2-character form of the month the histogram was
 created)
 mm_dd_yyyy\ (date of the histogram)
 nodeid.node (a file whose name includes the node ID
 number and “.node” file extension)

Figure 5 illustrates an exemplary directory structure for a NodeView.

In accordance with the present invention there is also a Parse_By_Hour process that sorts
20 all of the binary traffic logs into new files organized by date and time. As shown in Figure 2, each Mobitex traffic log 200 has a date stamp. The traffic logs, however, do not necessarily arrive at NCC 10 from the network in chronological order. The Parse_By_Hour process looks at each log's date stamp and copies the entire traffic log into a file set up for that day and hour. For each day there are preferably 24 files, one for each hour in the day. Of course, other
25 segmentation schemes for the logs may be implemented as deemed suitable under the particular circumstances. As the binary traffic logs are processed, they are preferably deleted from the disk

(TRANAL1, Partition 2). The “hourly” files are stored on TRANAL1, Partition 2, in a directory structure as follows and as shown in Figure 6:

```
Data Store:\
  traflog\
    year\ (4-character form of the year the histogram was created)
      month\ (2-character form of the month the histogram was
        created)
          mm_dd_yyyy\ (date of the histogram)
            hh.hour (a file whose name includes the hour of the day
              and “.hour” file extension)
```

In the preferred embodiment, sixty days of traffic logs are stored in this form. Typically, this much information will not fit on a single hard drive and thus the data is preferably split up over multiple disks, each with the same structure. The most recent files are preferably stored on the first disk and are moved to another disk as they become older. In this way, the Parse_By_Hour process need only point to one disk. When retrieving the stored hourly files later, it may be necessary to search across multiple disks in order to find the target date. Files more than sixty days old are preferably automatically compressed to save space and then are permanently archived onto compact discs.

Figure 7 shows the logical view of data that is stored for a typical HostView histogram in accordance with the present invention. That is, each file of Figure 4 can be viewed logically as the data structure of Figure 7. Specifically, as traffic logs are received from NCC 10, the histogram for the current day’s traffic logs is updated continuously. Thus, for a HostView file, each time a traffic log is received for a particular host, a count is incremented in the time “bin” that matches the time of the traffic log. As shown in Figure 7, the time bins are preferably 5 five minutes long, thereby providing a granularity of 5 minutes in a given 24 hour period. Of course, the granularity can be increased or decreased depending on the intended use of the data. In

addition to showing that an MPAK passed through a particular host at a particular time, the present invention also captures for the histogram the traffic state (see element 226 in Figure 2) of the MPAK, which includes the possible states of: OK, from mailbox, in mailbox, no transfer, illegal, congested and error. The number of MPAKs that have been designated to have a positive acknowledgement (POSACK) is also preferably tracked. That is, in HostView, TRANAL preferably keeps track of the total number of MPAKs passing through a host, as well as the number of MPAKs of each of the several possible states and the number of MPAKs requiring positive acknowledgement.

Thus, throughout the course of a day, each host file for that day is continuously updated so that by the end of a 24-hour period the whole day's traffic for all hosts is recorded in a form whereby a graphical histogram can be easily and quickly generated. Figure 8 illustrates an exemplary display screen 800 including a pair of histograms in accordance with present invention. Charts 805 and 810 plot the number packets or MPAKs versus time, in this case a 24-hour period, of which only the first 9 hours have been plotted. Chart 805 represents traffic in the host that is being passed from the network to the host, and chart 810 represents traffic in the host that is being passed from the host to the network. Which way the traffic is passing can be gleaned from the traffic log itself by looking at, for example, the A-party and B-party components of the log.

Towards the bottom of exemplary display screen 800 are pull down menus for selecting the date and host for which histograms are desired. A host can be selected by host MAN or by host name. Also, as shown in Figure 1, a host may be connected to more than one MOX. Thus, there is also preferably provided a pull down menu to select a histogram for all MOXs that the host is connected to. Still further, since the state of the MPAK is recorded as part of the traffic

log parsing/histogram generating process, TRANAL preferably also gives the user the option of selecting a graph of any of the different types of possible states as well as a graph showing the total number of MPAKs regardless of MPAK state. A separate graph may also be plotted for the MPAKs that require positive acknowledgement. Methods for graphing a data set like that that
5 shown in Figure 7 are well-known to those skilled in the art.

Of course, those skilled in the art will appreciate that both charts 805 and 810 need not be displayed at the same time. For example, the charts could be displayed on different pages or one of the charts may not be displayed at all. Additionally, since the present invention has been described as providing 5-minute granularity, the present invention preferably also provides the ability "zoom in" at selected time periods so that the higher resolution can be seen on the display.
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Similar charts can be generated for viewing traffic that pass through nodes using the NodeView histogram files, and for displaying traffic in the entire network.

A chart of the capacity or traffic of the links connecting the several nodes of network 100 may also be generated in accordance with the present invention. More specifically, since the present invention can analyze traffic logs and detect the traffic through any host or network node,
15 it is also within the scope of the present invention to graphically display traffic or capacity on node links. Each traffic log contains the number of bytes that the MPAK contained. Since the traffic log also includes the time the log was created, it is possible to deduce, roughly, when the MPAK was transmitted over a certain link. Thus, one can then calculate the number of bytes or
20 bits (per minute or second) that travel over the link over a period of time. In the context of the present invention, links not only include links between nodes, but may also include radio channel links and IP and X.25 links and Front End Processor (FEP) capacity. An FEP may be a

programmable or non-programmable switch between the network and customer host and may or may not do protocol conversion or provide gateway services.

Figure 9 illustrates exemplary steps for producing a HostView histogram in accordance with the present invention. Those skilled in the art will appreciate that the steps described are for generating a histogram for a single host, but that these steps are applicable and scalable to generate histograms for all hosts in a network, such as Mobitex network 100. At step 902, a daily histogram file for a host is created. Then at step 904, NCC 10 is checked to determine if a new traffic log is available. If no new logs are available, step 906, the process returns to step 904. If a new log is available, the process continues with step 908, at which the new log is downloaded from NCC 10 and saved, at least temporarily. The traffic log is then, at step 910, analyzed or parsed to determine the time the MPAK passed through a host and the entry and exit nodes of the associated MPAK. At step 912 it is determined whether the MPAK, for a particular host, was being passed into the network or was being passed from the network. This information is necessary if the two charts 805 and 810 are to be generated. At step 914, the host histogram file is then updated by incrementing a "state" counter (which includes a positive acknowledgement counter) and a total counter for the appropriate time "bin" of the histogram. Logically, this is an update to an array such as the one shown in Figure 7. Finally, at step 916, the traffic log itself is deleted, leaving only the histogram data as evidence of the traffic log. Thus, the histogram can be easily broadcast over a local network for, e.g., use by network operators/engineers, without having to generate a histogram from the raw traffic log data itself, thereby saving time and local network bandwidth.

Figure 10 shows a flowchart of exemplary steps for practicing the NodeView aspect of the present invention. At step 1002, empty histogram files for nodes are created. Then at step

1004, NCC 10 is checked to determine if a new traffic log is available. If no new logs are available, step 1006, the process returns to step 1004. If new logs are available, the process continues with step 1008, at which a new log is downloaded from NCC 10 and saved, at least temporarily. The traffic log is then, at step 1010, analyzed or parsed to determine the time the MPAK passed through its exit point and to detect the entry and exit points. At step 1012, the network path between the entry and exit points is determined, and at step 1014 the nodes along that path are determined. At step 1016, the histogram file of the nodes located along the path are updated. For Nodeview, charts analogous to charts 805, 810 are histogram charts of MPAKs travelling to higher levels of the network and MPAKs travelling to lower levels of the network. Finally, at step 1018, the traffic log itself is deleted, leaving only the histogram data as evidence of the traffic log. Thus, as in the case of HostView, the NodeView histogram can be easily broadcast over a local network for, e.g., network operators/engineers, without having to generate a histogram from the raw traffic log data itself, thereby saving time and local network bandwidth.

Figure 11 is a flowchart of steps for practicing the LinkView aspect of the present invention. At step 1102, daily histogram files for the several links in network 100 are created. Then at step 1104, NCC 10 is checked to determine if a new traffic log is available. If no new logs are available, step 1106, the process returns to step 1104. If new logs are available, the process continues with step 1108, at which a new log is downloaded from NCC 10 and saved, at least temporarily. The traffic log is then, at step 1110, analyzed or parsed to determine the time the MPAK passed through its exit point and to detect the entry and exit points. At step 1112, the path between the entry and exit points is determined, and at step 1114 the links along that path are determined, based on the known topology of network 100. At step 1116, the number of bytes

in the MPAK is determined. Then, at step 1118, the histogram files of the links along the path are updated based on the number of bytes travelling along the links. LinkView charts are analogous to charts 805, 810 in that the LinkView histograms plot traffic travelling to higher levels of the network and traffic travelling to lower levels of the network. Finally, at step 1120, the traffic log itself is deleted, leaving only the histogram data as evidence of the traffic log. Thus, as in the case of HostView and NodeView, the LinkView histogram can be easily broadcast over a local network.

The histograms generated by the present invention can be used by network operators to monitor and analyze network operation on a real or near real time basis. The HostView histograms may also be useful to personnel at companies or corporations (i.e., host operators) who may want to analyze the network use habits of their employees.

The foregoing disclosure of the preferred embodiments of the present invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many variations and modifications of the embodiments described herein will be obvious to one of ordinary skill in the art in light of the above disclosure. The scope of the invention is to be defined only by the claims appended hereto, and by their equivalents.

Further, in describing representative embodiments of the present invention, the specification may have presented the method and/or process of the present invention as a particular sequence of steps. However, to the extent that the method or process does not rely on the particular order of steps set forth herein, the method or process should not be limited to the particular sequence of steps described. As one of ordinary skill in the art would appreciate, other

sequences of steps may be possible. Therefore, the particular order of the steps set forth in the specification should not be construed as limitations on the claims. In addition, the claims directed to the method and/or process of the present invention should not be limited to the performance of their steps in the order written, and one skilled in the art can readily appreciate
5 that the sequences may be varied and still remain within the spirit and scope of the present invention.

WHAT IS CLAIMED IS:

1. A method of monitoring a packet-switched network using traffic logs, comprising the steps of:

(a) creating a histogram file;

5 (b) storing a traffic log generated by the network;

(c) determining the time of creation of the traffic log and its network entry and exit points; and

(d) updating the histogram file using at least the time of creation of the traffic log and at least one of the entry and exit points.

2. The method of claim 1, wherein the histogram file is a flat file, whereby direct and rapid access to stored data is effected .

3. The method of claim 1, wherein two histogram files are created, a first histogram being representative of traffic being passed into the network and a second histogram being representative of the traffic being passed from the network.

4. The method of claim 1, wherein the histogram file is representative of traffic passing to a host connected to the entry or exit point.

5. The method of claim 1, further comprising repeating steps (b) - (d) for at least a predetermined period.

6. The method of claim 1, further comprising analyzing the traffic log to determine state information of a packet associated with the traffic log, and updating the histogram with the state information.

7. The method of claim 1, wherein the histogram plots packets per minute versus time.

8. The method of claim 1, further comprising broadcasting from a server computer data representative of the histogram to a client computer.

9. The method of claim 1, wherein the network is a Mobitex network.

10. The method of claim 1, further comprising displaying a histogram based on data in the histogram file.

11. The method of claim 1, further comprising creating at least one histogram for each host of the network.

12. The method of claim 11, further comprising selecting for display the at least one histogram for a particular host.

13. The method of claim 1, further comprising monitoring a central location of the network for new traffic logs.

14. A method of monitoring packet traffic through a node of a packet-switched network using traffic logs, comprising the steps of:

(a) creating a histogram file for at least one node in the network;

(b) storing a traffic log generated by the network;

5 (c) determining the time of creation of the traffic log and its network entry and exit

points;

(d) determining a network path between the entry and exit points;

(e) determining whether the node falls along the network path; and

(f) updating the histogram file using at least the time of creation of the traffic log.

15. The method of claim 14, wherein the histogram file is a flat file.

16. The method of claim 14, wherein two histogram files are created, a first histogram being representative of traffic being passed towards a higher level of the network and a second histogram being representative of the traffic being passed towards a lower level of the network or outside the network.

17. The method of claim 14, further comprising repeating steps (b) - (f) for at least a 24 hour period.

18. The method of claim 14, wherein the histogram plots packets per minute versus time.

19. The method of claim 14, further comprising broadcasting, from a server computer, data representative of the histogram to a client computer.

20. The method of claim 14, wherein the network is a Mobitex network.

5

21. The method of claim 14, further comprising displaying a histogram based on data in the histogram file.

22. The method of claim 14, further comprising creating at least one histogram for each node of the network.

23. The method of claim 14, further comprising selecting for display the at least one histogram for a particular node.

24. The method of claim 14, further comprising monitoring a central location of the network for new traffic logs.

25. A method of monitoring packet traffic passing through a link connecting two nodes of a packet-switched network using traffic logs, comprising the steps of:

- 20
- (a) creating a histogram file for at least one link in the network;
 - (b) storing a traffic log generated by the network;
 - (c) analyzing the traffic log to determine the time of creation of the traffic log and its network entry and exit points;

- (d) determining a network path between the entry and exit points;
- (e) determining whether the link falls along the network path;
- (f) determining a number of bytes carried by the packet associated with the traffic log;

and

- 5 (g) updating the histogram file using at least the time of creation of the traffic log and the number of bytes.

26. The method of claim 25, wherein the histogram file is a flat file.

27. The method of claim 25, wherein two histogram files are created, a first histogram being representative of traffic being passed towards a higher level of the network and a second histogram being representative of the traffic being passed towards a lower level of the network or outside the network.

28. The method of claim 25, further comprising repeating steps (b) - (g) for at least a 24 hour period.

29. The method of claim 25, wherein the histogram plots bytes per second versus time.

30. The method of claim 25 further comprising broadcasting from a server computer to a client computer data representative of the histogram.

31. The method of claim 25, wherein the network is a Mobitex network.

32. The method of claim 25, further comprising displaying a histogram based on data in the histogram file.

5 33. The method of claim 25, further comprising creating at least one histogram for each link of the network.

34. The method of claim 25, further comprising selecting for display the at least one histogram for a particular link.

35. The method of claim 25, further comprising monitoring a central location of the network for new traffic logs.

36. A method of monitoring the operations of a packet-switched network, the network automatically generating traffic logs when a packet enters or exits the network, the method comprising the steps of:

- (a) detecting when new traffic logs are available at a network control center;
- (b) downloading the new traffic logs to a server computer;
- (c) updating at least one histogram file using information available from the new traffic
- 20 logs;
- (d) deleting the new traffic logs; and
- (e) making the at least one histogram file available to a client computer.

37. The method of claim 36, wherein the histogram file is a flat file.

38. The method of claim 36, wherein the histogram is representative of traffic passing through or via at least one of a host connected to the network, a node in the network and a link
5 connecting two nodes of the network.

39. The method of claim 36, wherein the network is a Mobitex network.

40. The method of claim 36, wherein the histogram includes information representative
10 of a state of each of the packets associated, respectively, with each of the traffic logs.

41. The method of claim 36, further comprising broadcasting the histogram file to a plurality of client computers.

42. The method of claim 36, wherein step (c) comprises incrementing a value in the
15 histogram file.

43. A method of analyzing the performance of a packet-switched network, the network automatically generating a traffic log each time a packet exits the network, each traffic log
20 including at least the time the traffic log was created, the addresses of the packet sender and packet recipient, and the entry and exit network nodes, the method comprising the steps of:

(a) collecting a plurality of traffic logs; and

(b) automatically generating a plurality of histograms, each histogram being based on information gleaned from the plurality of traffic logs,

wherein at least one histogram is representative of packet traffic passing through a host connected to the network.

5

44. The method of claim 43, wherein at least one histogram is representative of packet traffic passing through a node of the network.

45. The method of claim 43, wherein at least one histogram is representative of data traffic travelling over a link in the network.

46. The method of claim 43, wherein the histograms are stored as flat files.

47. The method of claim 43, wherein steps (a) and (b) are carried out on a server computer and at least one histogram is supplied to a client computer.

48. The method of claim 43, further comprising displaying at least one histogram on a computer display.

49. A system for monitoring a packet-switched network that automatically generates traffic logs, comprising:

(a) a network control center at which the traffic logs are collected; and

(b) a computer operable to (i) create a histogram file, (ii) store a traffic log generated by the network, (iii) determine the time of creation of the traffic log and its network entry and exit points, and (iv) update the histogram file using at least the time of creation of the traffic log and at least one of the entry and exit points.

5

50. The system of claim 49, wherein the histogram file is a flat file.

51. The system of claim 49, wherein the computer creates two histogram files, a first histogram being representative of traffic being passed into the network and a second histogram being representative of the traffic being passed from the network.

52. The system of claim 49, wherein the histogram file is representative of traffic passing through a host connected to the entry or exit point.

53. The system of claim 49, wherein the computer analyzes the traffic log to determine state information of a packet associated with the traffic log, and updates the histogram with the state information.

54. The system of claim 49, wherein the histogram is a plot of packets per minute versus time.

55. The system of claim 49, wherein the computer is a server computer and the server computer broadcasts data representative of the histogram to a client computer.

56. The system of claim 49, wherein the network is a Mobitex network.

57. The system of claim 49, wherein a client computer displays a histogram based on
5 data in the histogram file.

58. The system of claim 49, wherein the computer creates at least one histogram for each
host of the network.

59. The system of claim 49, wherein the computer monitors the network control center
for new traffic logs.

60. A system for monitoring packet traffic through a node of a packet-switched network
that automatically generates traffic logs, comprising:

- 15 (a) a server connected to a network control center; and
(b) a client connected to the server,

wherein the server is operable to (i) create a histogram file for at least one node in the
network, (ii) store a traffic log generated by the network, (iii) analyze the traffic log to determine
the time of creation of the traffic log and its network entry and exit points, (iv) determine a
20 network path between the entry and exit points, (v) determine whether the node falls along the
network path, and (vi) update the histogram file using at least the time of creation of the traffic
log.

61. The system of claim 60, wherein the histogram file is a flat file.

62. The system of claim 60, wherein the server creates two histogram files, a first histogram being representative of traffic being passed towards a higher level of the network and a second histogram being representative of the traffic being passed towards a lower level of the network or outside the network.

63. The system of claim 60, wherein the histogram is a plot of packets per minute versus time.

64. The system of claim 60, wherein the server broadcasts to the client data representative of the histogram.

65. The system of claim 60, wherein the network is a Mobitex network.

66. The system of claim 60, wherein the client displays a histogram based on data in the histogram file.

67. The system of claim 60, wherein the server creates at least one histogram for each node of the network.

68. The system of claim 60, wherein the client is operable to select for display the at least one histogram for a particular node.

69. A system for monitoring packet traffic passing through a link connecting two nodes of a packet-switched network that automatically generates traffic logs, comprising:

(a) a server; and

(b) a client connected to the server,

wherein the server is programmed to (i) create a histogram file for at least one link in the network, (ii) store a traffic log generated by the network, (iii) determine the time of creation of the traffic log and its network entry and exit points, (iv) determine a network path between the entry and exit points, (v) determine whether the link falls along the network path, (vi) determine the number of bytes carried by the packet associated with the traffic log, and (vii) update the histogram file using at least the time of creation of the traffic log and the number of bytes.

70. The system of claim 69, wherein the histogram file is a flat file.

71. The system of claim 69, wherein the server creates two histogram files, a first histogram being representative of traffic being passed towards a higher level of the network and a second histogram being representative of the traffic being passed towards a lower level of the network or outside the network.

72. The system of claim 69, wherein the histogram is a plot of bytes per second versus time.

73. The system of claim 69, wherein the server broadcasts to the client data representative of the histogram.

74. The system of claim 69, wherein the network is a Mobitex network.

75. The system of claim 69, wherein the client displays a histogram based on data in the histogram file.

76. The system of claim 69, wherein the server creates at least one histogram for each link of the network.

77. The system of claim 69, wherein the client is operable to select for display the at least one histogram for a particular link.

78. A system for monitoring the operations of a packet-switched network, the network automatically generating traffic logs when a packet enters or exits the network, the system comprising:

a server, in communication with a network control center, for detecting when new traffic logs are available at the network control center, for downloading the new traffic logs, for updating at least one histogram file using information available from the new traffic logs; and a client computer for displaying the histogram.

79. The system of claim 78, wherein the histogram file is a flat file.

80. The system of claim 78, wherein the histogram is representative of traffic passing through or via at least one of a host connected to the network, a node in the network and a link connecting two nodes of the network.

5

81. The system of claim 78, wherein the network is a Mobitex network.

82. The system of claim 78, wherein the histogram includes information representative of a state of each of the packets associated, respectively, with each of the traffic logs.

10

83. The system of claim 78, wherein the server broadcasts the histogram file to a plurality of client computers.

15

84. A system for analyzing the performance of a packet-switched network, the network automatically generating a traffic log each time a packet enters or exits the network, each traffic log including at least the time the traffic log was created, the addresses of the packet sender and packet recipient, and the entry and exit network nodes, the system comprising:

(a) a traffic log data base; and

20

(b) a computer, the computer operable to download traffic logs from the traffic log database and to generate and store a plurality of histograms, each histogram being generated from information gleaned from the plurality of traffic logs,

wherein at least one histogram is representative of packet traffic passing through or over at least one of a host connected to the network, a node of the network, and a link in the network.

85. The system of claim 84, wherein the histograms are stored as flat files.

86. The system of claim 84, wherein the computer is a server computer.

5

87. The system of claim 84, wherein the at least one histogram is supplied to a client computer.

ABSTRACT OF THE DISCLOSURE

A system for and method of analyzing the performance of a packet-switched network, the network automatically generating a traffic log each time a packet enters or exits the network and each traffic log including at least the time the traffic log was created, the addresses of the packet sender and packet recipient, and the entry and exit network nodes. A server collects a plurality of traffic logs, parses the available information therein and generates a plurality of histograms, each histogram being based on information gleaned from the plurality of traffic logs. The histograms may be representative of packet traffic passing through a host connected to the network, packet traffic passing through a node in the network or the amount of data that travels over a link between two nodes of the network. To increase the delivery speed of the histogram data from the server to a client, the histograms are preferably stored as flat files to achieve direct and rapid access to stored data.

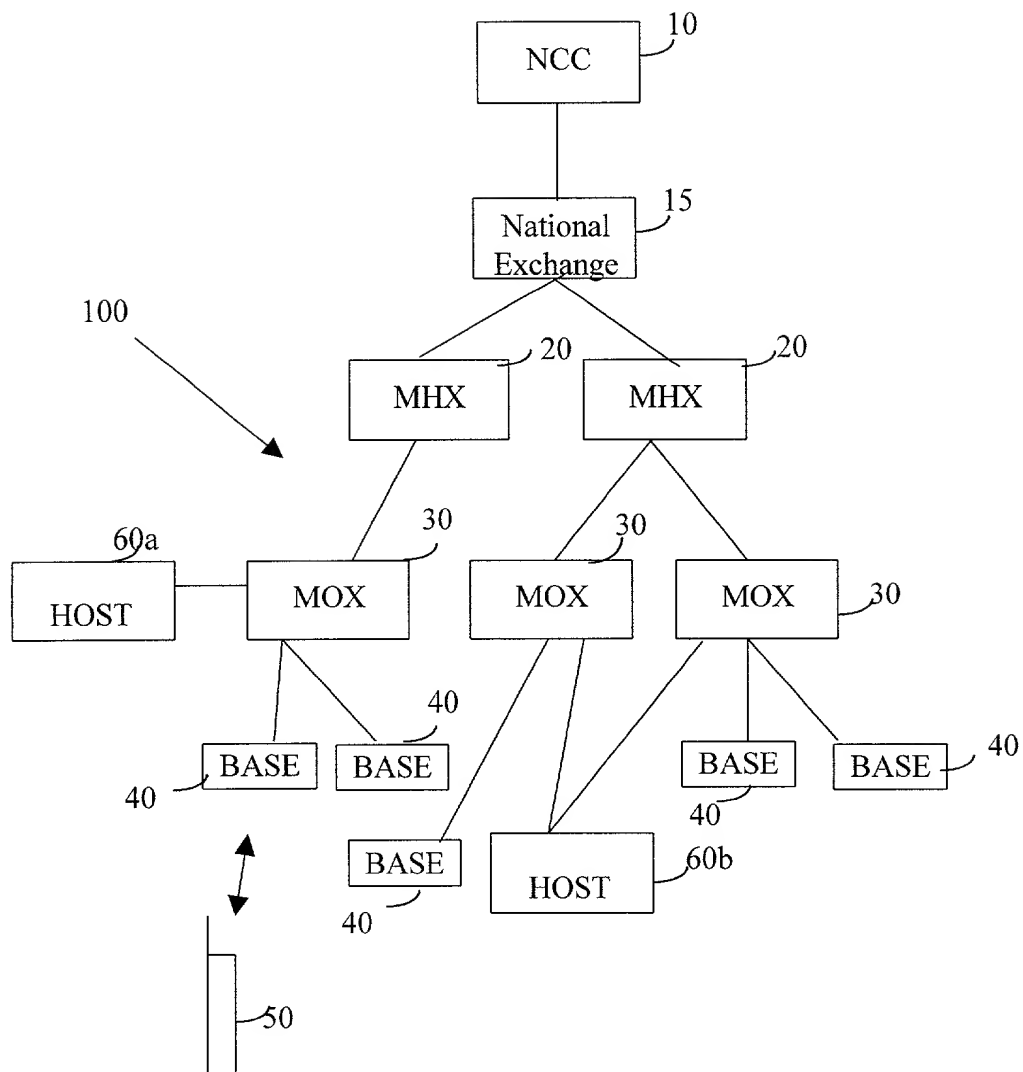


Figure 1

005207-20455350

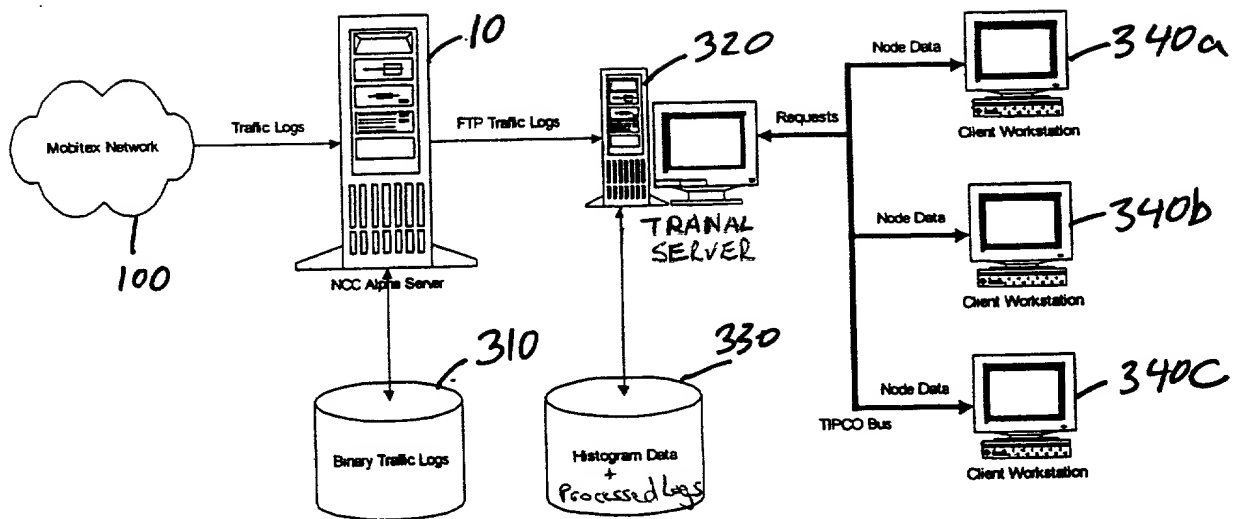


Figure 3

005207" 20756960

```
E:\
  host histograms\
    1999\
      11\
        11_31_1999\
          101039.0.host
          101039.1438.host
          101304.0.host
          ...
      12\
        12_01_1999\
          101039.0.host
          101039.1358.host
          101039.1438.host
          101304.0.host
          ...
        12_02_1999\
          101039.0.host
          101039.1224.host
          101039.1358.host
          101304.0.host
          ...
      ...
    2000\
      ...
      08\
        ...
        08_19_2000\
          101039.0.host
          101039.1224.host
          101039.1438.host
          ...
        08_20_2000\
          101039.0.host
          101039.1224.host
          101039.1358.host
          101304.0.host
          ...
        08_21_2000\
          101039.0.host
          101039.1224.host
          101304.0.host
          ...
      ...
```

Figure 4

```
D:\
  node histograms\
    1999\
      11\
        11_31_1999\
          11001.node
          1224.node
          ...
      12\
        12_01_1999\
          2.node
          11001.node
          1224.node
          ...
        12_02_1999\
          2.node
          11001.node
          1224.node
          ...
      ...
    2000\
      ...
      08\
        ...
        08_19_2000\
          2.node
          11001.node
          1224.node
          ...
        08_20_2000\
          2.node
          11001.node
          1224.node
          ...
      ...
```

Figure 5

LOGICAL VIEW OF HOSTVIEW HISTOGRAM DATA

Hour	Minute	OK	From Mailbox	In Mailbox	No xFer	Illegal	Congest	Error	Posack	Total
0	0	0	0	0	0	0	0	0	0	0
0	5	1.6	0	0	0	0	0	.4	2.4	4.4
0	10	13.2	0	0.6	0	0	1.4	.4	99.8	115.4
0	15									
:	:									
:	:									
1	0									
1	5									
:	:									
:	:									
23	0									
23	5									
:										
24	55									

Figure 7

005207 2045550

SCANNED, # 14

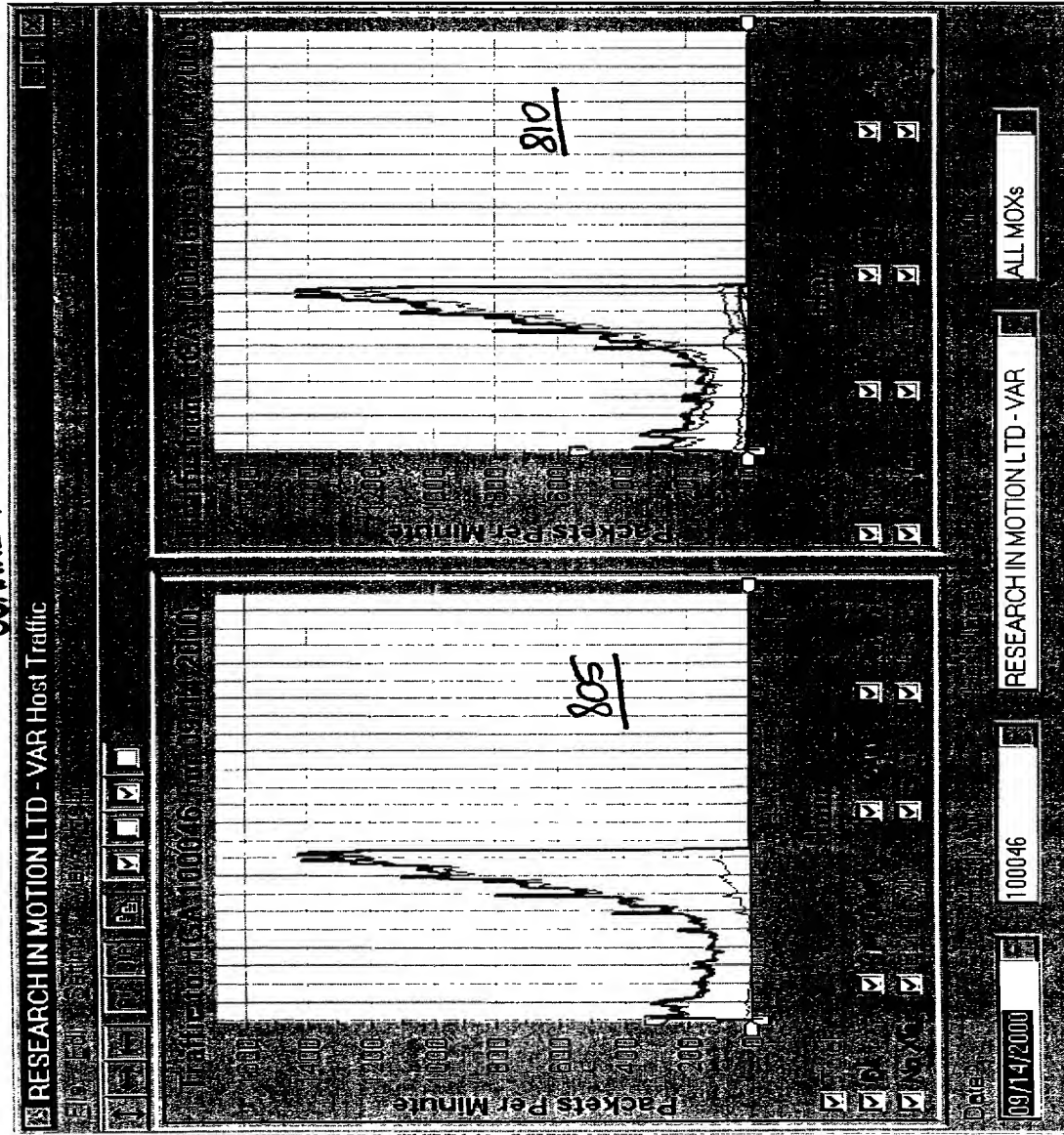


Figure 8

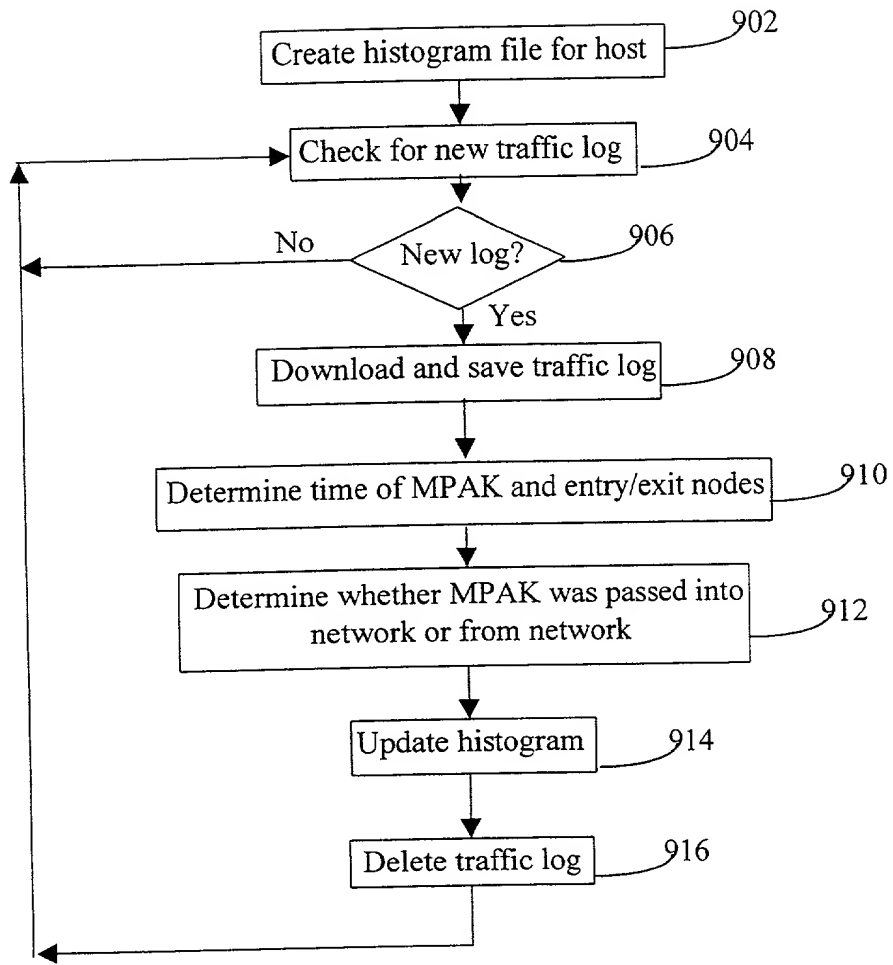


Figure 9

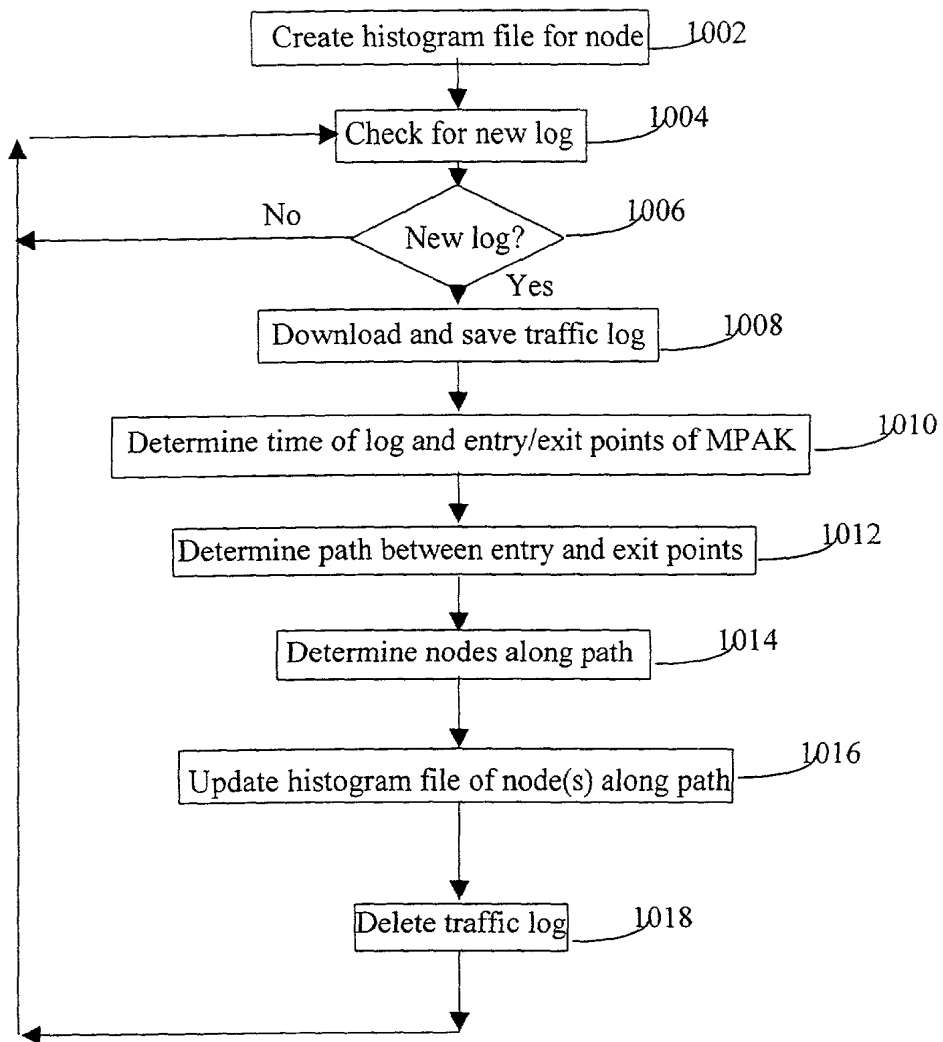


Figure 10

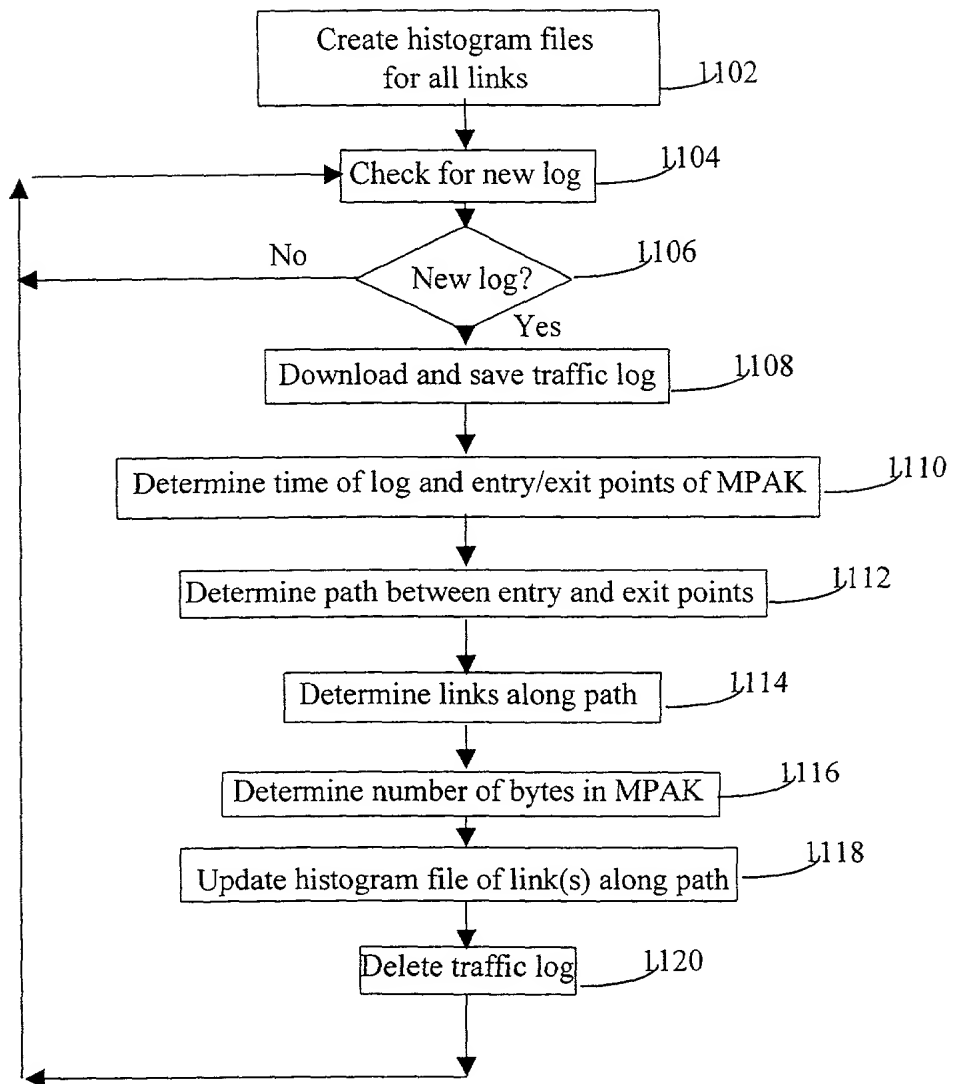


Figure 11

Docket No.

BS00-189

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled
NETWORK TRAFFIC ANALYZER

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____ and was amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)

(Filing Date)

(Application Serial No.)

(Filing Date)

(Application Serial No.)

(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of second inventor, if any Jeffrey D. Kashinsky	
Second inventor's signature	Date
Residence	
Citizenship	
Post Office Address	

000001-200405050

Full name of third inventor, if any Brian D. Kling	
Third inventor's signature	Date
Residence	
Citizenship	
Post Office Address	

Full name of fourth inventor, if any	
Fourth inventor's signature	Date
Residence	
Citizenship	
Post Office Address	

Full name of fifth inventor, if any	
Fifth inventor's signature	Date
Residence	
Citizenship	
Post Office Address	

Full name of sixth inventor, if any	
Sixth inventor's signature	Date
Residence	
Citizenship	
Post Office Address	